Scenario Planning for the Future: Highlighting Connections to New Technologies

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LINKING EMERGING TECHNOLOGIES to LONG RANGE TRANSPORTATION PLANNING

• Both States and MPOs develop long-range transportation plans (LRTPs)
• MTPs guide decision-making and investments across all modes of surface transportation over a 20+ year horizon
• Scenario planning techniques are often used to inform LRTP development
• During this 20+ year horizon, emerging Connected and Autonomous Vehicle technology may revolutionize transportation, making it important that long range plans start including plans for the infrastructure, data, etc. that regions will need to support this driving force
What is a “Connected” Car?

- **V2V**: Bi-directional information sharing between vehicles
- **V2I**: Bi-directional information sharing between a vehicle and the roadway
- **V2X**: Bi-directional information sharing between a vehicle and X (pedestrians, cyclists, trains, etc.)
Example V2V Safety Applications

- Emergency Electronic Brake Lights
- Forward Collision Warning
- Blind Spot / Lane Change Warning
- Left Turn Assist
- Intersection Movement Assist
- Do Not Pass Warning
- Etc., Etc.
Example V2I Applications

- Queue Detection and Warning
- Red Light Violation Warning
- Merge Assistance
- Emergency Vehicle Preemption
- Transit Signal Priority
- Eco Traffic Signal Timing
- Dynamic Driver Messaging
- ATM Integration
Methods of Connecting

- **Dedicated Short Range Communications (DSRC):**
  - WiFi for cars, very fast and reliable
  - Good for localized imminent collision warning and time sensitive data
  - .0002 s latency
  - Relatively short range (300 meters)

- **3G/4G Cellular:**
  - Nearly ubiquitous coverage
  - Less reliable communications
  - 1.5 – 3.5 s latency

- **5G Cellular (future):**
  - Still in draft technical specs but promising low latency, high reliability, high bandwidth
  - Works from much of the existing cellular infrastructure
  - Performance TBD

Image Source: http://www.automotive-eetimes.com/design-center/why-80211p-beats-lte-and-5g-v2x
Early Implementation Example

• Audi PRIME traffic light feature
• Interface to centralized signal control system in several cities
• Counts down Red to Green phase change
• Uses cellular communications
Implications of Connected Vehicle Deployment

• Safety
  • V2V alone may address up to 81% of crashes involving unimpaired drivers (27K fatalities, 1.8M injuries, 7.3M property damage)²
  • V2I alone may address up to 19% of crashes involving unimpaired drivers²

• Mobility
  • Improved traffic flow and reduce delays (27%)¹
  • Increased awareness of and access to multi-modal choices
  • More direct, actionable information for drivers (re-routing, incidents, weather, etc.)

• Environmental
  • Combined Eco-Signal apps may reduce CO2 and fuel consumption (11%)¹
  • Signal and freeway lane management combined reduce fuel consumption (22%)¹

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Other Potential CV Implications

• Exposure and access to multi-modal travel options
  • Increased transit and facility demand
  • More desire for non-motorized travel options (bikes, pedestrian paths, etc.)
• Dynamic routing increases capacity but more trips on secondary roads
• Parking apps can reduce “hunting” for parking and some urban congestion
• Potential to reduce or eliminate infrastructure
  • Variable dynamic message, lane management, and traditional signage
  • Traffic signals
• Increased needs for monitoring and contingency planning
  • System outage or failures become more significant
  • System security becomes critical
Transportation Needs

Reduce recurring congestion
I-66 corridor currently experiences average travel speeds of approximately 40 mph during the peak periods

Increase travel reliability
I-66 has a PTI value over 3 during both the morning and evening peak periods

Reduce non-recurring congestion
Incident duration in the Northern Region has averaged 52 minutes over the last year

Reduce crashes
Facilities within the VCC experienced 2,061 crashes (5 fatal and 70 severe injury crashes) in 2013

VDOT Performance Measures & Goals

Delay
Vehicle Hours of Delay
GOAL: Reduce VHD

Reliability
Planning Time Index
GOAL: Reduce PTI

Duration
Incident Duration
GOAL: Reduce incident duration by 5 min in 5 years

Safety
Number of crashes
GOAL: Reduce fatal & injury crashes by 3% per year (from 2010 baseline)

CV Applications (Priority indicated within parenthesis)

Advanced Traveler Information
Work Zone Alerts for Drivers and Workers
Incident Scene Alerts for Drivers
Red Light Violation Warning System
Queue Warning
V2V – Forward Collision Warning
V2V – Emergency Electronic Brake Light
Parking Availability
Probe Enabled Traffic Monitoring
Integrated Traffic Signal System
Transit Signal Priority
Emergency Vehicle Preemption
Virginia’s CV Deployment Strategy

UTC Program
NOVA Testbed
Smart Road Testbed
Build, Develop, Test
Operate and Maintain Applications
Long Term Operations & Maintenance

WE ARE HERE
Widespread Adoption
Performance Measurement
VCC Maturity
VCC Open Cloud Environment

VDOT Resources
- Northern VA Traffic Operations Center
  - TOC Controllers Operating:
    - Signal Phasing
    - HOV Lanes
    - Ramp Meters
    - Changeable Signs
    - Incident Management
    - Maintenance Activity
    - Etc.
- VDOT Data Sources
  - Incident Reports
  - Weather Events
  - Work Zone Locations
  - Dynamic Message Sign Content
  - Limited Traffic Data
- New VDOT Traffic Operations Support Applications
  - TOC Support Applications:
    - Queue Detection and Warning
    - Weather Event Detection
    - Probe-Enabled Monitoring
    - Incident Detection and Mgmt
    - Work Zone Safety Mgmt
    - Etc.

VDOT Resources
- VTTI Data Center
- 3rd Party App Provider
- RSE's

Other National Deployments
- US DOT Research
  - Data Exchange

System APIs
- Message Queues
- Redis Cache
- Persistent Data
- VCC Cloud Computing Environment

Mission Control
- System Monitoring
- Asset Management
- Data Visualization

Android Cell Phone
- Visual Display
- Audio Display
- Text to Speech Msgs
- Speech to Text Reports

New VDOT Traffic Operations Support Applications
- TOC Support Applications:
  - Queue Detection and Warning
  - Weather Event Detection
  - Probe-Enabled Monitoring
  - Incident Detection and Mgmt
  - Work Zone Safety Mgmt
  - Etc.

VCC Cloud Computing Environment

3rd Party App Provider

RSE's

DSRC

OBE's

Cellular
VDOT

October 20, 2016
DRAFT

Connected Vehicle Program Plan
Cloud Data Portal – Automation of Existing and Anticipated Sources
Reduce Traditional Infrastructure
Provide Connected and Automated Vehicle Roadway Infrastructure
Provide Connected Vehicle Pilot Application
<table>
<thead>
<tr>
<th>SAE level</th>
<th>Name</th>
<th>Narrative Definition</th>
<th>Execution of Steering and Acceleration/Deceleration</th>
<th>Monitoring of Driving Environment</th>
<th>Fallback Performance of Dynamic Driving Task</th>
<th>System Capability (Driving Modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Human driver</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>Human driver and system</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>System</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>All driving modes</td>
</tr>
</tbody>
</table>

Human driver monitors the driving environment

Automated driving system ("system") monitors the driving environment

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Difficult AV Challenges
Approaches to AV Deployment

• Auto manufactures appear to favor an incremental, evolutionary approach
  • Add features and capability while building confidence
  • Advance and build upon connected concepts
  • Allow for adaptation of drivers and public perception
  • L2 vehicles are in production now, some L3’s announced for 2018-2020, L4’s 2020-2030

• Non-traditional auto makers (tech companies) favor a revolutionary approach
  • Straight to level 4, some driving modes, likely geo-fenced, precision mapped, and conditional (good weather and lighting, etc.)
  • Driver adaptation is less critical to success
  • Will benefit from better infrastructure (roads, lines, connected signals, etc.)
  • True level 5 (anywhere, anytime, any condition) will take time if ever
Implications of Automated Deployment

• Implications depend on type of automation and level of adoption
  • Estimates of adoption and saturation rates vary significantly and saturation takes time
  • Product positioning, fleet use, ownership models, luxury vs. masses, affordability
  • User acceptance not a “given”, 65% of unexposed drivers are unwilling to relinquish control to an automated vehicle
  • Perception of safety and security, high profile events

• Safety Implications
  • Significant safety improvements are possible, particularly with increased saturation
  • May eliminate most of driver error crashes (90%)
    • Impaired, aggressive, inattentive, and generally risky driving are reduced or eliminated
  • May introduce new risks
    • System failures, cybersecurity risks, reduced seat belt use, mixed fleet interactions, more travel
More Implications of AV Deployment

- Impact on roadway capacity
  - May initially be a dis-benefit
    - Safe operating parameters or non-aggressive tuning for rider acceptance
    - Mixed fleet driver expectation issues
  - Expect deployments on freeway systems first
  - Up to 2X increased capacity at high penetration levels due to shorter headways, narrower lanes, higher speeds, coordinated movement
  - Simulation shows benefits not achieved until 50-75% of fleet is equipped and cooperating with non-linear increases as penetration nears 100%
  - With acceptance and penetration, operating parameters can be sharpened to add more capacity
  - Less non-recurring congestion due to crash reduction, reduced rubbernecking, efficient weave/zipper
More Implications of AV Deployment

• On travel demand
  • Increases due to positive experience, ability to multi-task, access to non-drivers
  • May significantly reduce regional air and rail travel
  • Estimates of 5-20% increase in VMT with 50% market penetration, up to 35% increase with 95% penetration (particularly with L4/L5)

• Impact on transit
  • May increase transit use by providing first/last mile access
  • Improves efficiency and reliability when applied to transit vehicles
  • May supplement or replace transit over time
More Implications of AV Deployment

• Enables robo-taxi and ride sharing fleets
  • Highly desirable model for automakers (limits risk and manages expectations)
  • Eliminates driver labor from the ride share economics
  • Reduced parking requirements in activity centers
  • Potential for many dead head runs – bigger issue off hours and rural areas
  • Who manages cleaning, vandalism, messes and will riders accept cameras as a management tool

• Effects on families/lives
  • Reduced ownership (maybe a 1 car family instead of 3 cars), less expense
  • Enables travel for non-drivers
  • Live/work further away from activity centers
  • Impact on public health - potentially reduces willingness to bike, walk, transit